(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 May 2002 (30.05.2002)

PCT

(10) International Publication Number
WO 02/42555 A1

(51) International Patent Classification[7]: D21G 7/00, D21H 23/26

(21) International Application Number: PCT/FI01/01014

(22) International Filing Date:
22 November 2001 (22.11.2001)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
20002592 24 November 2000 (24.11.2000) FI

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,

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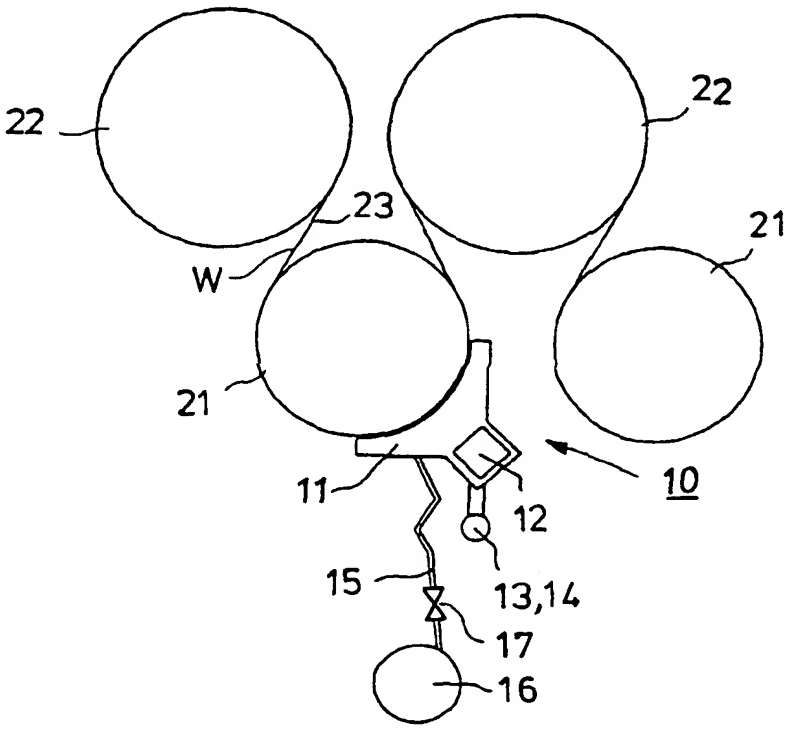
(54) Title: METHOD AND DEVICE FOR CONTROLLING THE MOISTURE OR COATING QUANTITY PROFILE IN A PAPER WEB



(57) Abstract: The invention relates to a method for controlling the moisture profile of a paper web. In the method, the narrow-scale moisture profile is controlled by profiling nozzles (11) of a profiling device (10) which cover part of the width of the web and, in the method, desired variations of the moisture profile are corrected by the profiling nozzles (11). The invention also relates to a method for controlling the coating quantity profile of a paper web. In the method, the narrow-scale coating quantity profile is controlled by profiling nozzles (11) of a profiling device (10) which cover part of the width of the web and, in the method, desired variations of the coating quantity profile are corrected by the profiling nozzles (11). The invention further relates to a device for controlling the moisture profile or the coating quantity profile of a paper web. The device (10) comprises profiling nozzles (11) for controlling narrow-scale moisture profile variation, which cover a desired part of the width of the web, to correct desired variations occurring in the profile in the width direction of the web.

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GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

Method and device for controlling the moisture or coating quantity profile in a paper web

The invention relates to a method for controlling the moisture profile of a paper web according to the preamble of claim 1.

The invention also relates to a method for controlling the coating quantity profile of a paper web according to the preamble of claim 3.

The invention also relates to a device according to the preamble of claim 8.

In paper machine concepts, the on-line process is becoming increasingly more important both in new machines and when old paper machines are modified. In on-line finishing, in particular in on-line multi-nip calendering of demanding grades, totally new demands are set for the profiles of paper, in particular for moisture and tension profiles, especially in connection with small-scale control of the moisture and tension profiles. New profile control methods are needed for these in order that the quality of paper and runnability should be on a satisfactory level, for example, in multi-nip calendering. In this respect, it is particularly difficult to control the narrow-scale moisture profile, for which no technically advantageous or economical methods are known in the state of the art. The narrow-scale variations of the moisture profile occurring in wide machines are particularly problematic.

Narrow-scale profile variations are either stationary or momentarily wandering in the width direction of the web. Narrow-scale variations are caused, for example, by the condition of a press felt, which may become striped upon ageing, and by colour stripes on a cylinder surface in a dryer section. In addition, basis weight variations may cause narrow-scale moisture profile variation. Distinguishing

between wide-scale and narrow-scale profile variation is, of course, a relative conception and varies with different paper grades; in the manufacture of board, a profile variation of, for example, 100 mm may be regarded as narrow and that of 300 mm as wide, in the manufacture of printing paper, a profile variation of, for example, 50 mm may in turn be regarded as narrow and that of 150 mm as wide, and in the case of sanitary tissues, a profile variation of, for example, 25 mm may be regarded as narrow and that of 75 mm as wide. In this description, by narrow-scale profile variation is primarily meant a profile variation of less than 100 mm, even less than 25 mm in width, and in the profiling of the coating quantity, a profile variation of even less than 10 mm in width.

In the prior art, various arrangements are known for controlling the moisture profile of paper, but these are applicable to profiling of the entire area across the width of the web and to wide-scale control of the moisture profile of the paper web. In the prior art, a moisturizing beam is known in which regulating nozzles are used and by means of which the wide-scale variation of the moisture profile of the paper web in the width direction thereof is controlled. With respect to the prior art relating to moisturizing of the web, reference is made to *US Patents 3,948,721* and *5,286,348.*

The narrow-scale variations of the moisture profile cannot be controlled by the methods known in the state of the art, for example, by means of a moisturizing beam, a steam box, an infrared device, a headbox, a deflection-compensated roll, because their profiling width is too great to control narrow-scale moisture profile variation. In addition, they are suitable for use primarily across the entire width of the web.

As known from the prior art, attempts have also been made to control the problems described above such that the paper web has been overdried, thereby eliminating the narrow-scale peaks occurring in moisture profile variation. This is very costly, because it has not been possible, for example, to directly calender the

overdried web but it has been necessary to re-moisturize the web by a plane moisturizer before calendering, It shall be noted in particular that it is difficult to remove moisture at the final stage of drying, overdrying thus being rather expensive and difficult to accomplish.

One problem area in the state of the art has also been the profiling of the coating quantity, the local increase of which has presented a particular problem. As known in the state of the art, it has been possible to locally reduce the quantity of coating, for example, by changing the rod or blade load.

An object of the invention is to provide a method and a device which, when used, make it possible to solve the above-noted drawbacks and problems known in the state of the art.

A particular object of the invention is thus to create a method and a device by which it is possible to control the narrow-scale moisture profile of paper.

An object of the invention is also to provide a method and a device which are suitable for control of the moisture profile in part of the area of a web in the width direction thereof.

A further object of the invention is to create a method and a device which allow the quantity of coating to be profiled.

With a view to achieving the objects described above as well as the ones coming out later, the method according to the invention is mainly characterized in that which is set forth in the characterizing part of claim 1 and/or 3.

The device according to the invention is in turn mainly characterized in that which is set forth in the characterizing part of claim 8.

In accordance with the invention, part of the width of the web is covered with movable profiling devices, thereby providing a profiling arrangement which treats part of the width of the web and in which the variations, i.e. peaks, caused by the narrow-scale variation in the moisture profile are controlled based on measurement. In the arrangement in accordance with the invention, the narrow-scale variation of the moisture profile is controlled by means of a movable profiling element, i.e. profiling nozzle, of the profiling device such that moisture is applied to areas which are drier, thereby eliminating the undesired phenomenon which is caused by moisture streaks due to the variation of basis weight and which also gives rise to machine-direction tension variation. At the same time, it is possible to use drying profile correction to remove moist peaks. Profiling elements of the profiling device can be placed in several groups in the width direction of the web, one group for each operating zone in the width direction of the web.

The apparatus used in the invention makes it possible to profile narrow peaks and, in the invention, both drying and moisturizing spray nozzles are advantageously placed on the same guide.

In the narrow-scale moisture profile control system in accordance with the invention, only a fraction of the width of the web, for example, 10 % is covered with narrow, for example, 10-millimetre-wide profiling elements, most preferably hot air or liquid nozzles. The profiling element, or the nozzle, comprises one nozzle unit or, when needed, several component nozzles substantially one after the other in the running direction of the web. The nozzles are movable in their operating zone in the cross direction of the web and, in accordance with the invention, the nozzles are moved to cover only the worst peaks, in particular the peaks which are the worst from the viewpoint of on-line calendering. Thus, for example, in a 10-metre-wide machine, it is possible to remove, for example, 100 of the worst peaks.

When desired, the invention may also be used in wider areas, but it is particularly suitable for profiling narrow moisture profile variations. The drying capacity freed by means of the invention can be used, for example, for increasing the speed of the machine, for shortening of the dryer section.

The number of the nozzles used in connection with the invention is chosen according to the profile demands of the next process stage, i.e. how bad profile peaks must be removed, and on the basis of the quality of the original moisture profile.

In connection with the invention, for example, heat radiation, hot air, steam, liquid, gas or another suitable medium is used as the profiling medium.

In accordance with the invention, the profiling members, for example, profiling hot air nozzles, are placed, for example, in connection with a reversing cylinder or roll of a single-wire draw.

In the device in accordance with the invention, the nozzles move on a guide and a feed is connected to the nozzles, and the device comprises a control arrangement and a moving mechanism, for example, a pushing means moving on a screw guide, which moving mechanism may be, for example, inside a guide beam. The device in accordance with the invention covers, for example, less than half of the width of the web with its effective area and most appropriately 5 to 30 %.

One advantageous choice for the moving mechanism of the profiling nozzles is to use devices which are attached to slide guides and placed in moving zones and which are moved by means of a push-pull rod connected to a threaded rod. A profiling medium, for example, liquid or hot air is passed into the profiling nozzle through a medium duct, for example, a compressed-air hose from a common distributor pipe. The moving is accomplished, for example, such that the machine width is divided into zones of 1 to 3 metres, in the area of which zones individual

nozzles move. This arrangement allows the length of the medium ducts leading from the distributor pipe to the nozzles to be limited so that it is reasonable. In connection with the invention it is also possible to use other types of moving mechanisms and moving devices.

The nozzles are thus advantageously moved by a pushing means connected to a rotatable threaded rod, which pushing means goes and pushes nozzles to locations indicated by profile measurement data according to where in the width direction of the web the worst peaks are situated. The pushing means is controlled such that it knows the positions of the nozzles based on counting of the turns of the threaded rod, in which connection, when a new peak has appeared in the profile, the pushing means thus re-arranges the nozzles. The nozzles and their auxiliary devices are placed, for example, beneath two successive reversing rolls in a single-wire draw, for example, beneath rolls of the type registered by the applicant under the trademark VacRoll, such that profile errors wider than the width of a single nozzle can also be profiled with a uniform response.

When desired, the nozzles can also be provided with control valves, in which case level adjustment can be carried out according to each individual nozzle. This is, however, not necessary because the profile can also be substantially improved by on-off valves in any case. In that connection, adjustment is carried out by adjusting the level of the trunk duct.

The arrangement in accordance with the invention provides many significant benefits: Active correction of the moisture profile with a large number of peaks is achieved while, at the same time, the average solids content is increased, thereby providing more capacity. Furthermore, the invention makes it possible to reduce the need for overdrying arising from profiles, whereby more capacity is obtained directly. In accordance with an advantageous feature, the invention does not require very large trunk air ducts, for example, of the size range of ϕ 200 to 600 mm. In addition, the structure in accordance with the invention can be

accomplished advantageously because the nozzles can be manufactured, for example, as simple sheet metal work.

The machine automation needed in connection with the invention is simple since the nozzles placed on the guide are moved, in accordance with an advantageous application, by a pushing means connected to a turn-controlled threaded rod, in which connection the control system knows the position of each nozzle.

The control automatics and electronics of the system are most appropriately placed in their entirety outside the machine hood at a location where the conditions are advantageous. Thus, the system can be very advantageously added afterwards to any machine.

Moreover, updating of the system is inexpensive and easy because, when needed, new nozzles, for example, of a different width or more nozzles are just placed on the guide and the control program is changed.

In the control system of the moisture profile of paper in accordance with the invention, a simple mechanism is adjusted, controlled and used, thereby enabling a desired part of the width of the web to be profiled.

The control system in accordance with the invention can also be used for profiling of coating.

In connection with the method in accordance with the invention, Non-Scan measurement is used particularly advantageously, said measurement using a high-resolution measuring beam which measures all the time across the entire width of the web. Advantageously, it is also possible to use measurement of the Mini-Scan type, which uses a full-width measuring beam which oscillates at an amplitude of, for example, 100 mm, thus, most appropriately with the same spacing as there are sensors in the beam, which is a quicker measuring means than a measuring device

of one sensor traversing across the entire web. In the arrangement in accordance with the invention, measurement is arranged after a press and after a dryer section as profile measurement to provide a control signal for a profile actuator. When desired, it is also possible to use measurement after a calender, but this is not necessary.

In the following, the invention will be described in greater detail with reference to the figures of the appended drawing, in which

Figure 1 is a schematic view of an exemplifying embodiment of the placement of profiling hot air nozzles.

Figure 2 schematically shows the moving of profiling nozzles in moving zones.

Figure 3 schematically shows the connection between moisture, tension and basis weight profiles.

Figure 4 schematically shows two-stage correction of the moisture profile, and

Figure 5 shows a control system of profile actuators.

As shown in Fig. 1, a profiling device 10 in accordance with the invention is placed in connection with a reversing cylinder or roll 21 of a single wire draw and in the figure a paper web W runs while supported by a wire 23 along a meandering path from drying cylinders 22 of an upper row to the reversing rolls 21 of a lower row. The profiling device 10 can also be placed at another suitable location in a dryer section or, when profiling the quantity of coating, before or after a coating device at an appropriate location, for example, on the surface of the web before the coating device or on the surface of the roll of the coating device or on the surface of the web. In the device 10 in accordance with the invention, profiling nozzles 11 move on a slide guide 12 and, based on counting the turns of

a threaded rod 13, a pushing means 14 knows the positions of the nozzles 11. The profiling nozzle, or the profiling element 11, may be formed of one unit or of several component nozzles situated substantially one after the other in the running direction of the web. Hot air or another profiling medium is passed into the profiling nozzles 11 through a medium duct, for example, a compression air hose 15, from a common distributor pipe 16. The reference numeral 17 designates a control member, for example, a valve of the medium duct 15. The nozzles 11 can also be moved by another suitable means and their position can also be monitored by another method suitable for the purpose. The nozzles 11 are moved to cover the worst peaks of narrow-scale profile variation based on the profile data obtained from a measuring device (not shown).

As shown in Fig. 2, the profile actuators 10 are placed in moving zones Z, a desired number of profiling nozzles 11, for example, 1 to 100 nozzles, most appropriately 5 to 30 nozzles, being placed in each moving zone Z, and the width of each moving zone Z being 0.5 to 5 m, most appropriately 1 to 3 m, depending on the width of the machine. In each zone, the nozzles 11 of the profile actuator 10 are moved so that they are at the worst peaks occurring in the moisture profile. The nozzles 11 can be either drying or moisturizing. In profiling the quantity of coating, the nozzles 11 apply an additional amount of coating to the surface of the web at the peaks found in narrow-scale profile variation and indicating too small a quantity of coating.

Fig. 3 shows the connection between moisture, tension and basis weight profiles. The X-axis represents shrinkage and the Y-axis represents solids content and, at the same time, the behaviour of the web in the longitudinal direction shown in the adjacent figure. The moisture profile curve is denoted with the reference numeral 31, the basis weight profile is denoted with the reference numeral 32, and the tension profile is denoted with the reference numeral 33. When the solids content of paper increases, as shown with the curve 41, dry streaks 34 in the web W start to shrink first and more quickly than moister streaks 35. The more plastic moist

streaks 35 undergo permanent deformations. The web W contracts locally according to the moisture streaks 35 due to the variation of the basis weight profile 32 and, at the same time, the plastic properties of the web are concentrated unevenly in accordance with the original moisture profile 31. With the progress of local shrinkage, the tension profile 33 is formed which remains in the paper web W when elongations are frozen at the end of drying. The curve 41 illustrates the shrinkage behaviour of the web W as a function of solids, and the solids content is 40 to 50 % in the initial situation, about 60 % when shrinkage begins, and over 90 % at the end. The arrows 36 show straining of the web W and its cross-direction stresses.

As shown in Fig. 4, in two-stage correction of the moisture profile, a press moisture profile 51 coming from the press comprises large-scale and narrow-scale profile variation. First a steam box 52 or another appropriate prior-art method is used for profiling, thereby bringing the large-scale profile variation under control, and after that in a press moisture profile 53 there is narrow-scale moisture profile variation which has peaks which, in accordance with the invention, are profiled by the moisture profiling device 10, for example, hot air nozzles 11 of the impingement hood type (Figs. 1 & 2), whereby the moisture profile can be levelled into a moisture profile 55 having a desired uniformity.

In the schematic control system chart shown in Fig. 5, a measurement device 61 has feedback 62 to a steam box 63 and feedforward to a profile actuator 10. The steam box 63 is placed on a press 65, and a measurement 66 is carried out after the press 65, said data being also transmitted to the profiling device 10. After that, the web is dried in a drying stage 67, after which a traversing measurement is carried out by a measuring device 68, which also has feedback 69 to the profile actuator 10 to control it such that narrow-scale profile variation can be eliminated. After that, the web can be calendered in a calender 71, which may be followed, when desired, by a new traversing measurement by a measuring device 72.

Above, the invention has been described with reference to some of its advantageous exemplifying embodiments only, to the details of which the invention is, however, not by any means intended to be narrowly confined.

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Claims

1. A method for controlling the moisture profile of a paper web, **characterized** in that, in the method, the narrow-scale moisture profile is controlled by profiling nozzles (11) of a profiling device (10) which cover part of the width of the web and that, in the method, desired variations of the moisture profile are corrected by the profiling nozzles (11).

2. A method according to claim 1, **characterized** in that, in the method, the moisture profile is measured and the profiling nozzles (11) are moved by a moving member (13, 14) to cover the areas of the greatest variation.

3. A method for controlling the coating quantity profile of a paper web, **characterized** in that, in the method, the narrow-scale coating quantity profile is controlled by profiling nozzles (11) of a profiling device (10) which cover part of the width of the web and that, in the method, desired variations of the coating quantity profile are corrected by the profiling nozzles (11).

4. A method according to claim 3, **characterized** in that, in the method, the coating quantity profile is measured and the profiling nozzles are moved to cover the areas of the greatest variation of the profile indicating too small a coating quantity.

5. A method according to any one of claims 1 to 4, **characterized** in that, in the method, profiling is accomplished by means of profiling nozzles (11) which operate in zones (Z) situated in the width direction of the web.

6. A method according to any one of the preceding claims, **characterized** in that, in the method, profile variations are controlled over part of the width of the web, said part being 5 to 50 % of the entire width of the web.

7. A method according to claim 1 or 2, **characterized** in that, in the method, drying profile correction is used for removing moist peaks and/or moisturizing profile correction is used for removing dry peaks.

8. A device for controlling the moisture profile or the coating quantity profile of a paper web, **characterized** in that the device (10) comprises profiling nozzles (11) for controlling narrow-scale moisture profile variation, which cover a desired part of the width of the web, to correct desired variations occurring in the profile in the width direction of the web.

9. A device according to claim 8, **characterized** in that the device (11) further comprises a moving mechanism (13, 14) for moving the profiling nozzles (11) and means (15, 16, 17) for passing a profiling medium into the profiling nozzles (11).

10. A device according to claim 8 or 9, **characterized** in that the device (11) is placed in connection with a reversing cylinder or roll (21) of a single-wire draw in a dryer section to control the moisture profile.

11. A device according to claim 8 or 9, **characterized** in that the device is placed in connection with a coating device or in the substantial vicinity thereof to control the coating quantity profile.

12. A device according to any one of claims 8 to 11, **characterized** in that the moving mechanism of the profiling elements (11) is a pushing means (14) connected to a threaded rod (13) and that the profiling nozzles (11) are movably attached to slide guides (12).

13. A device according to any one of claims 8 to 12, **characterized** in that a profiling medium is passed into the profiling nozzle (11) through a medium duct (15) from a distributor pipe (16) common to the profiling nozzles (11).

14. A device according to any one of claims 8 to 13, **characterized** in that the profiling nozzles are provided with a regulating member to regulate the degree of profiling.

15. A device according to any one of claims 8 to 14, **characterized** in that the device comprises several profiling nozzles (11) which cover 5 to 50 % of the width of the web.

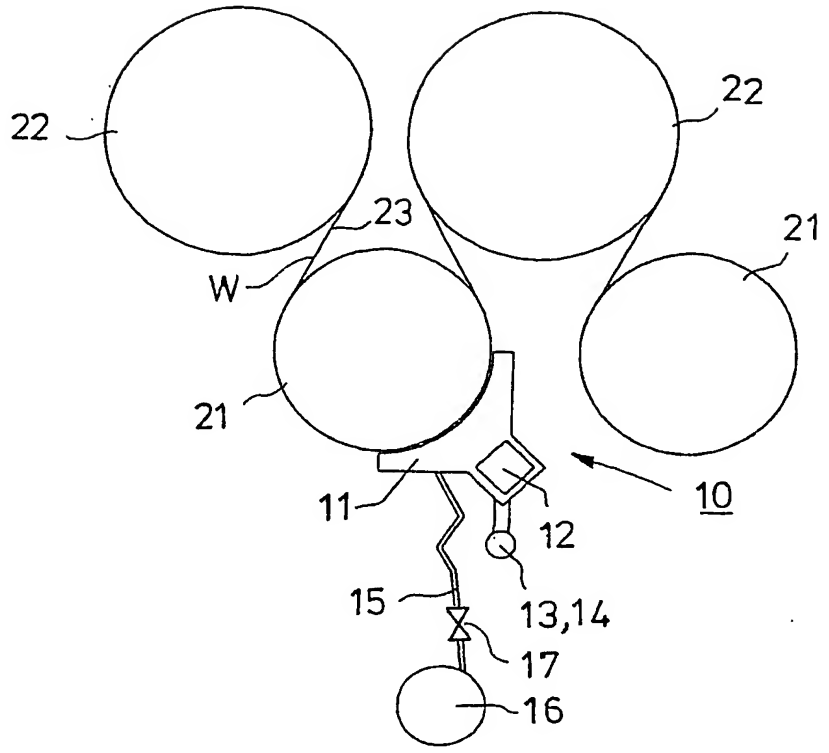

FIG. 1

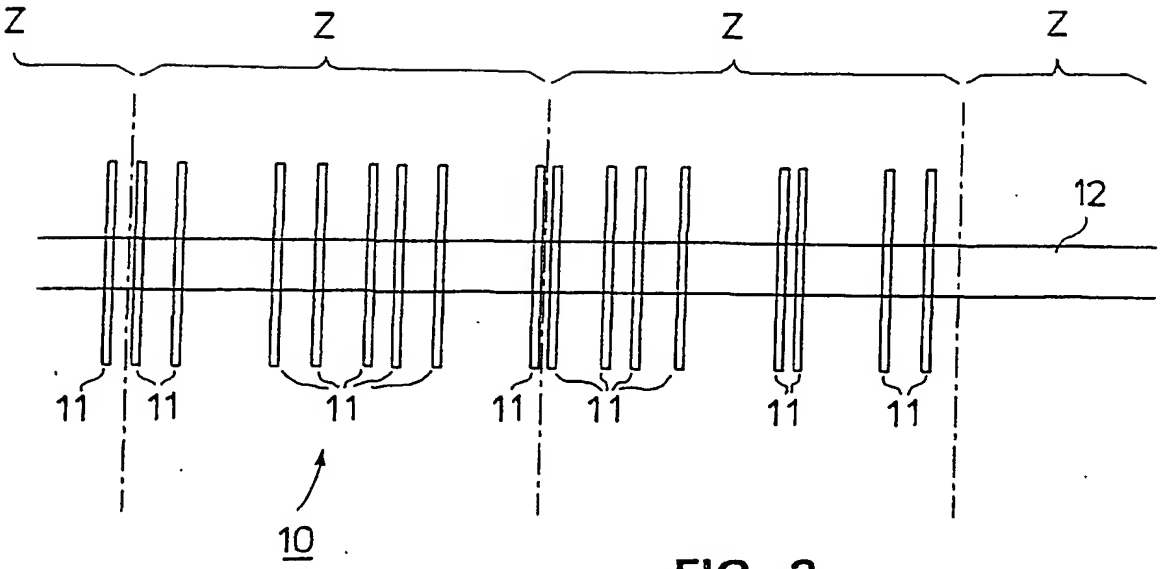

FIG. 2

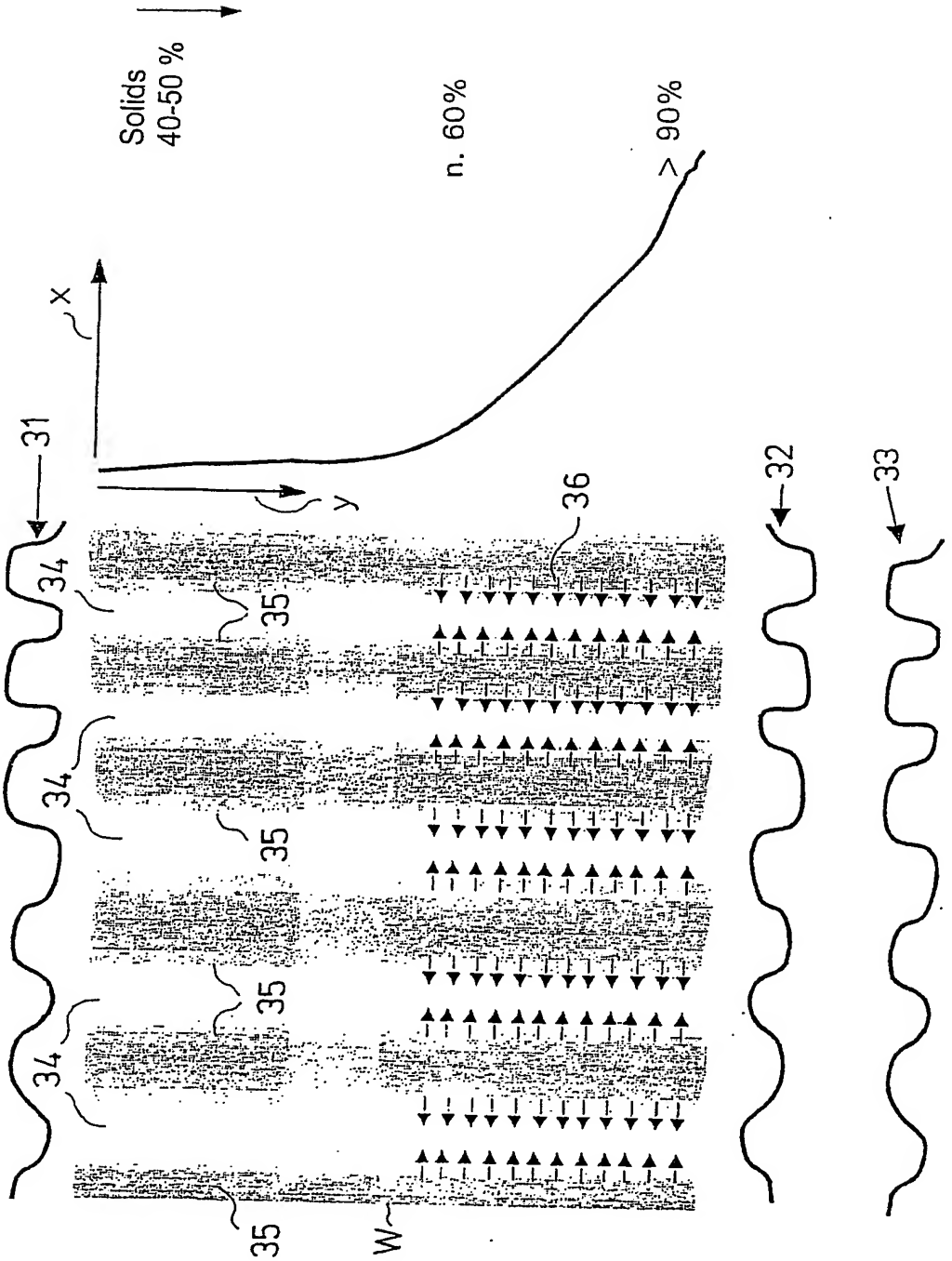

FIG. 3

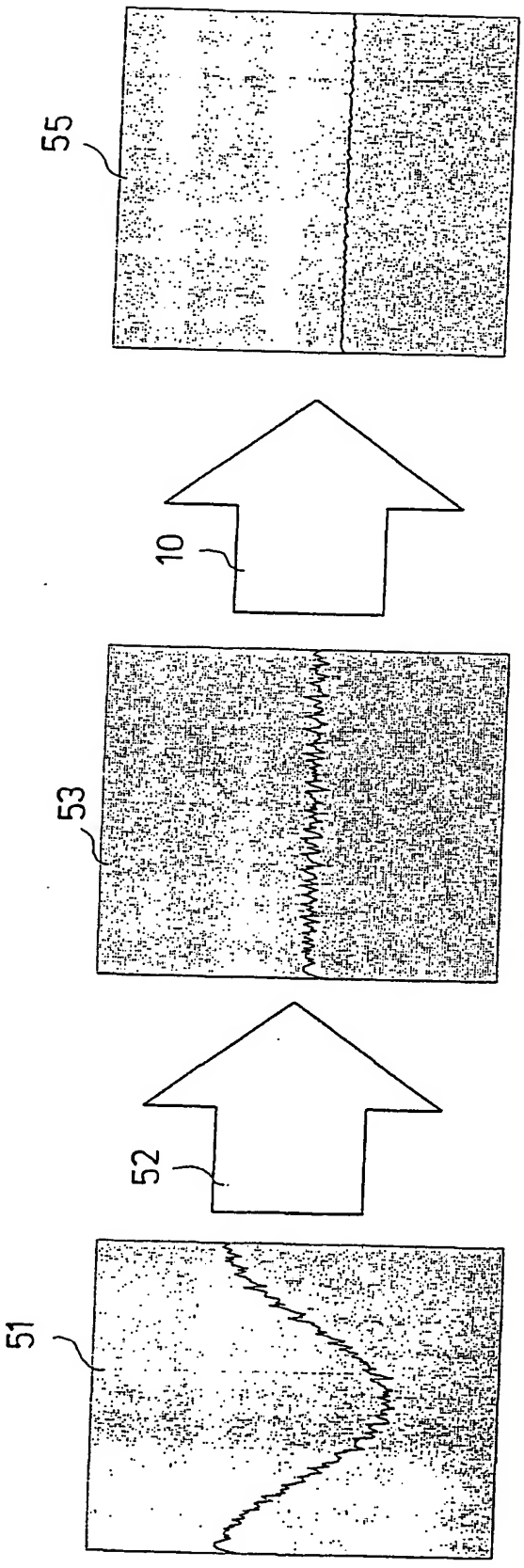

FIG. 4

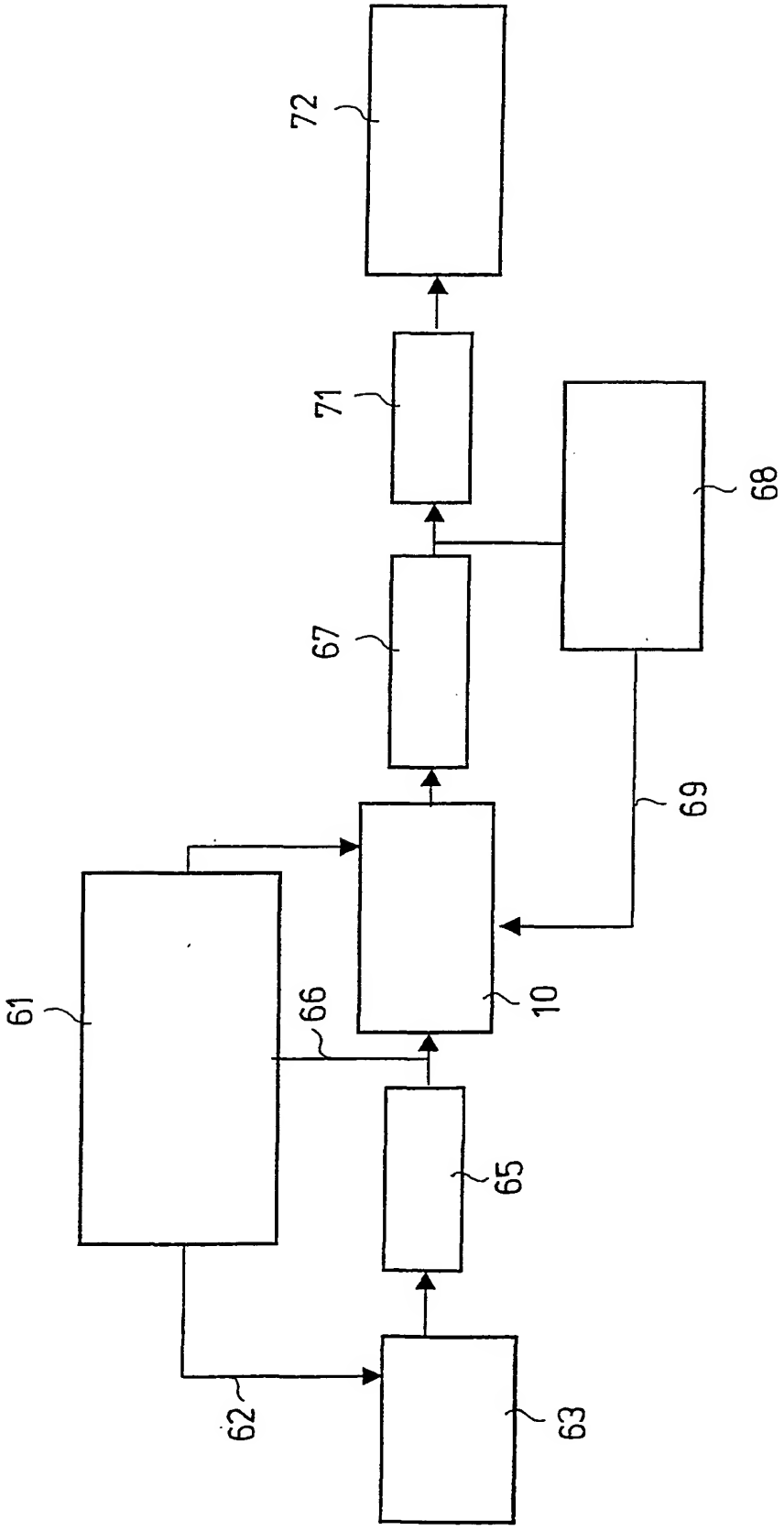

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/01014

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: D21G 7/00, D21H 23/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: D21G, D21H, D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 1585846 A (A. AHLSTROM DEVELOPMENT GMBH), 11 March 1981 (11.03.81), page 4, line 101 - line 117, figure 15, claim 1 --	1-15
A	US 5685955 A (LEIGRAF ET AL), 11 November 1997 (11.11.97), figure 1, claim 1, abstract --	1-15
A	US 6006443 A (KARVINEN), 28 December 1999 (28.12.99), figure 2, abstract --	1-15
A	DE 3741680 A1 (PAGENDARM GMBH), 22 June 1989 (22.06.89), figure 2, abstract --	1-15

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
25 February 2002	26.02.02
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Nina Bergström/ELY Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/01014

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1020559 A2 (VOITH SULZER PAPIERTECHNIK PATENT GMBH), 19 July 2000 (19.07.00), abstract -- --------	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/01/02

International application No.
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